Chapter 3

CLASSIFICATION OF SOFTWARE PACKAGES

3.1 Introduction

In this chapter, we construct eight different categories of instructional softwares and discuss the characteristics of each of these categories. There is a large and growing number of computer software packages available to support the teaching and learning of many topics in mathematics. These packages can be used in a variety of ways, and a classification should be useful. One simplistic way of attempting to classify software packages is to label them as good or bad. One of the problems in doing this is that it is difficult for instructors to agree on what makes a good software package, and the classification is then subjective. Another way of classifying software packages is by the topics they teach. The problem here is that while many software packages are designed to teach just one topic, some panoramic packages support the learning of a large range of topics. It is difficult to give a complete list of these. A different way of classifying software packages is by the style of learning they support. This is how software packages in this dissertation are classified. One package may provide a game to be played, for example, while another may best be used by instructors to illustrate points they want to make while teaching.

3.2 Exposition packages

Exposition packages are used by the instructor to demonstrate or explain an idea or a technique to the whole class. The use of these packages stimulate mathematical discussions in the classroom between instructors and learners, and between learners themselves. A sufficiently big monitor or data projector is required so that all learners can see clearly. Here the computer is used as a visual aid. In this category, the instructor may ask learners many questions, and he/she remains in control of the sequence and the rate of teaching. The instructor decides on what idea is to be presented next, how and for how long it needs to be discussed before the next idea is introduced.

Table 3.1. Examples of exposition packages.

Package	**Level**	**Description**
Spring and string	Tertiary	Ordinary differential equation software.
Complex numbers	Tertiary	Evaluate complex expressions.
Graph theory	Tertiary	Allows learners to experiment with undirected graphs.
Integral	Tertiary	Computes the numerical value of a definite integral by various techniques.
Sequence	Tertiary	Creates sequences and shows values of successive terms numerically and graphically.
Lepack	Tertiary	Sets realistic problems involving the solution of a large system of linear equations.

Table 3.1. Continuation.

Package	Level	Description
Moves	Secondary	Teaches geometrical transformation-rotation, translation, reflection and enlargment.
Singos	Secondary	Provides a model that explains the meaning of sines and cosines of all angles.
Solve	Secondary	Explains the solution of linear equations.
Discrete mathematics	Tertiary	Discrete mathematics package.
Phaser	Tertiary	Differential equations package.
Macmath	Tertiary	Solves first-order differential equations.
MATT graphical display package and differential equation solver	Tertiary	Solves differential equations through graphics.
Maclogic	Tertiary	A first-order logic software package.
Solving quadratic equations	Tertiary	Supplements the teaching of the concept of solving quadratic equations.
EZQ	Tertiary	Solves first and higher-order differential equations and systems of equations.
Math 246 **programmes**	Tertiary	Ordinary differential equations software.
Matrix calculator	Tertiary	Manipulates matrices.

Table 3.1. Continuation.

Package	Level	Description
Matrix master	Tertiary	Inputs. stores. inserts or deletes a row of a matrix. It performs elementary row operations.
Ordinary differential equations	Tertiary	Solves first and second-order differential equations.
Differential equations graphics package	Tertiary	Solves first and second-order differential equations.

To integrate this category of packages into the teaching process. the instructor must first teach the content in class using the traditional method. and can then use a computer software package to further illustrate it. Alternatively. the instructor can use the package from the start to introduce a concept. Here the instructor keeps full control of the educational programme. The instructor can use the package for any concept that he thinks can best be illustrated by the package. By being exposed to visual illustrations of the mathematical concepts. learners may be able to understand these concepts better. This may lead them to feeling successful in learning the course material. and thereby cultivates a more positive attitude towards mathematics. According to Walker [39. p487]. "the capability of seeing the results obtained on the screen is considered to be an evolutionary step in the strategy of learners' learning. Learners can see the cause of error. even in an erroneous action. and this can lead them to another presentation of the solution".

Walker [36. p419] maintains that. "introducing these packages into the teaching process requires a considerable re-arrangement of the classroom activities and requires a lot of time". There is the danger that instructors may not want their jobs usurped. and since these packages aim to mimic human teaching activities this is an understandable fear. Another danger is that instructors may have little time or incentive to keep up to date with developments in computing, and feel unable to make proper use of these packages. Graham [13, p3] is of the opinion that, "instructors do not want their normal routines disrupted by, for example, the need to be responsible for the scheduling of the use of these packages".

3.3 Problem-solving packages

Quoting Wiebe [40, p17], "a problem is a situation demanding resolution for which there is no immediate solution, and problem solving is a process of searching for and finding solutions to problems". Problem solving consists of moving from a given initial situation to a desired goal situation. A different way of saying this is that problem solving is a process of designing and carrying out steps to reach a goal. It serves as a preparation for the real world because it teaches learners the necessary skills for dealing with problems they are bound to be confronted with. These packages help learners to search for a solution to a problem. Kelman [20, p5] maintains that, "problem-solving packages help learners to explore problem situations, keep track of what they have learnt and find patterns in what remains to be done". They enable learners to attack a problem using different strategies. Problem-solving packages create practice situations that help learners to gain skills in the process of selecting a strategy for solving a problem.

Table 3.2. Examples of problem-solving packages.

Package	**Level**	**Description**
Geometric supposer	Secondary	Does geometrical constructions.
Math pac	Secondary	Provides review and interactive problem solving in algebra.

Table 3.2. Continuation.

Package	**Level**	**Description**
Visicalc	Secondary	Software for topics such as functions and equations.
TK solver	Secondary	Solves somewhat complex problems. This is an automatic problem solver.
Mind over matter	Secondary	Helps develop problem-solving skills.
Wizard	Primary	Gives learners practice in basic mathematics.
Guesstimation	Primary	It provides practice in numeration and estimation.
Mathpert	Tertiary	Allows learners to focus on correct strategy of problem solving in calculus and algebra.
Geometric constructor	Tertiary	Does geometrical constructions.

Problem-solving packages may be used when learners have difficulties in selecting the best strategy to solve a problem. Learners are given a new-found freedom to explore. to test strategies. and to play. all of which are at the heart of problem solving. According to Kelman [20. p3]. "problem-solving packages teach learners to think. and hence prepare them for the real world". They enable learners to work with challenging and complicated problems. Learners engage in a kind of problem solving in which the process. not the product is paramount. They may come to recognise that there are often many correct answers for a given problem. The correct answer becomes less important than the process of exploring the content of the solution.

Instructors can create complex problem -solving environments in which learners can act more like real-world problem solvers. They enable learners to solve the standard homework problems in less time. thereby allowing the instructor to cover more material or the same material in more depth. Williams [42, p2] says that, "problem-solving packages reinforce the need for understanding mathematical concepts and mastering computational skills". They enable learners to develop and apply problem-solving strategies to geometry, logical reasoning, classification, measurement, fractions and decimals, and other mathematical content. Strategies include using trial and error, making an organised table, drawing a diagram, and looking for a pattern.

Howard [18, p1] says that, "when using problem-solving packages, learners enjoy solving word problems easily and dependably. They may become happy campers in the forest of problem solving. Instructors may also gain the advantage of a logical, consistent approach to word problems that applies across the curriculum and at all grade levels". These packages enable learners to experience success in solving problems. Learners may thus gain confidence in doing mathematics and develop persevering and inquiring minds. They may also grow in their ability to communicate mathematically and develop a point of view about what it means to learn mathematics and to solve problems in mathematics.

3.4 Graphical packages

Kelman [20, p95] says that, "mathematics education has for some time been dominated by numbers while graphs and geometric interpretations have played a secondary role". This is because very few instructors are used to or familiar with visualising mathematical concepts by geometric interpretations. Graphical packages promise to change all that. For this to happen, mathematics instructors as well as their learners, need experience with graphical packages. A graphical package is a package that contains a variety of tools which allow learners to create and design pictures and graphs on the screen, and to print them. There are now a variety of graphical packages available for special applications that may be of interest to instructors and to learners of mathematics. Packages that display data easily on the screen and that graph mathematical functions can be used in a variety of ways in mathematics classrooms.

Table 3.3. Examples of graphical packages.

Package	Level	Description
Turtle graphics	Secondary	Draws complex designs.
SIGAD	Tertiary	For learning three-dimensional geometry.
Locus	Secondary	Draws loci on the screen.
Graph	Secondary	Draws graphs.
Function graph plotter	Secondary	Draws graphs.
Build	Secondary	Draws pictures composed of cubes.
Algebra and function plotter	Secondary	Helpful in the study of functions.
Interpreting graphs	Primary and secondary	Gives practice for matching line graphs to description of events in the physical world.
Taylor	Tertiary	Graphs the first 20 Maclaurin polynomials.
Polar	Tertiary	Plots polar equations of the form $r = r(t)$. t is an angle.
Quick-Graph	Tertiary	Enhances the teaching of mathematical functions.

Table 3.3. Continuation.

Package	Level	Description
Gyro graphics	Tertiary	Provides interactive real time animated 3-dimensional graphing of mathematical objects: Surfaces, space, curve, vectors and vector fields.
Geometer's sketch pad	Secondary and tertiary	Offers dynamic visual images to help learners' understanding of the topic.
Graphic calculus	Tertiary	A graphical programme numerically based.
Master grapher	Tertiary	Explores fundamental concepts related to 2-dimensional functions.
Plot pak	Tertiary	Graphs discontinuous functions and straight line asymptotes for functions.
Calculus-Pad	Tertiary	Displays, manipulates and performs operations on a variety of functions in calculus.
Number forms	Secondary	For exploring and learning mathematics.

One way of integrating graphical software packages into the teaching process is to do it after presenting information. The instructor first teaches the content in the traditional way. Learners are taught to first draw all kinds of graphs and then to use a computer to check these or to do more difficult ones. Another way of integrating graphical software packages arises when there is a need to save time or if some graphs are impossible to draw by hand or look complicated on the board, such as graphs in three dimensions. This is probably the most common way of using it.

Instructors may use graphical packages to create pictures that model mathematical concepts. Yet another way of using computer graphics is for instructors to illustrate proven theorems with specific examples. and also to use accurate pictures to suggest possible new results to prove. Instructors can encourage learners to put visual images of mathematical phenomena on the computer for study. manipulation and exploration.

Graphical packages allow learners to position and size rectangles. ovals and other regular shapes. draw irregular shapes using a mouse. fill closed shapes in desired colours or shadings. and to draw lines of various thickness and colours. Learners can use the graphic capabilities of computers in a wide range of ways. ranging from traditional graphing activities to informal geometric exploration to sophisticated three-dimensional design. Learners can also visualise problem elements by using two-dimensional drawing programmes. For example. learners can draw a geometry problem which asks them to calculate the angles at which a ladder of a given length leans against a house at various heights. Using a more sophisticated three-dimensional drawing programme. learners can draw three-dimensional figures. manipulate them. and solve problems involving such shapes. An example of this is LOGO. a high level computer language with a powerful graphics component called turtle graphics. It can be used to teach programming to elementary high school learners. geometric and algebraic concepts to high school mathematics learners and vectors to high school and tertiary learners.

Graphical packages enable instructors and learners to visualise geometric and trigonometric relationships. These are normally difficult to do without the package. According to Walker [34. p640]. "in the special classroom equipped with the trichromic projector. it is possible to expand the image appearing on the computer screen on a large wall screen. This allows the use of graphic facilities of the computer to show. in a limited time. a number of different examples". Learners are freed from the drudgery of sketching and erasing lines and curves on graph paper. and they can then focus on concepts behind graphs and formulae instead.

Quoting Vockel [32. p66]. "automated plotting of functions makes it possible for learners to solve many more problems than would otherwise be possible in the same amount of time". This increase in the efficient use of academic learning time may lead to a better understanding of topics under consideration and to a more productive application of principles to higher order problem solving. Graphical packages enable learners to explore mathematical concepts. thereby. shaping their intuition. and teaching them to enjoy the experimental side of mathematics as well. When learners are able to plot related graphs and see the effects whenever variables are changed. they may gain a deeper insight into the relationship between functions and their graphs. Graphical packages may thus enable learners to visualise what the instructor is saying quickly. Geometry packages enable learners then to experiment with figures. arriving at conjectures that may be proved in the end.

The use of geometrical figures with the accuracy that is offered by graphical packages enhances the understanding of mathematical concepts being presented. Kimmins [21. p2] states that. "three-dimensional graphical packages allow learners to view solids from different perspectives. thus helping learners to see models they had difficulty visualising otherwise and at the same time improving their spatial visualisation capabilities".

3.5 Tutorial packages

To function as a tutor. the computer must be programmed by people who are experts both in programming and in the subject matter. Here the computer presents subject material and the learners respond. The computer evaluates the responses. and from the results of the evaluation. determines what to present next. At its best. the computer tutor keeps complete records on each learner. Tutorial packages attempt to teach new information and new conceptual understanding. A tutorial lesson starts by presenting information which guides the learner to an understanding of the information and ideas presented. This is followed by a series of questions. When learners successfully answer these questions. the computer presents more information. When they are unsuccessful in responding to the questions. the computer either gives a hint or a repetition of previously stated details followed by more questions. Tutorial packages function in a role similar to an instructor explaining information or concepts to the learner. They present new information. and attempt to teach the material through dialogue with the learner. The computer provides information in small segments on the screen. At least some of these screens prompt learners for a response. The computer's next step depends on the learner's response. The best computerised tutorial packages employ a strategy called branching programmed instruction. Possible branching options include:

- supplying the learner with the next piece of information in the learning sequence.
- sending the learner to a remedial branch of the programme to permit review or to explain the information in a different manner. and
- allowing the learner to seek help by getting definitions. clarifications or other information necessary to solve a problem.

Table 3.4. Examples of tutorial packages.

Package	**Level**	**Description**
Mastering mathematics: decimals	Secondary	Presents information to learners and then asks a question about that information.
Word-problem tutor	Secondary	Solves word problems.
Vectors and scalars	Tertiary	Helps learners understand properties of scalars and vectors.
Geometry concepts	Secondary	Provides practice in identifying and spelling geometric terms.
Equations	Secondary	Solves algebraic and linear equations.
Integer	Primary	Teaches addition. subtraction. multiplication and division of positive and negative numbers.

Tutorial packages may be integrated into the lesson at the beginning by presenting information. According to Grabe [12. p80]. "tutorial packages can be integrated during the second stage of instruction to guide learning as learners struggle to understand the information". This can be given in the form of exercises that cover the content presented in class.

Vockel [32. p35] says that. "tutorial packages provide immediate and interactive feedback which is often difficult to provide in a written format". By presenting one screen at a time. the computer can sometimes focus attention more precisely on a single concept. By using tutorial packages. learners tend to work for longer and with more interest. Tutorials can more precisely tailor the rate of progress and the content of presentations to the needs of the individual learner. Immediate adaptations in instruction can be made. and learners can interact with the tutor. Quoting Stephen [29, p17], "with well- designed software packages, the computer tutor can easily and swiftly tailor its presentation to accommodate a wide range of learners' differences".

There is a danger in using these packages. Sometimes the screen is not big enough to contain all the information needed to present an idea. Segmenting concepts onto separate screens can be distracting. Tutorials are limited, not only by the imagination of the designers, but also by the computer technology itself.

3.6 Drill and practice packages

Packages that fall under this category are those that give learners practice in various areas such as operations with real numbers, number sequences and factorising. They are designed to provide practice in concepts and skills learners have already learnt. Such packages are usually designed to pre-test learners, and on the basis of these results, provide the appropriate level of practice. Most drill and practice packages randomly generate mathematics problems and then check if the answer is correct. Learners are provided with problem sets, presenting a sequence of skills to be practised. These packages are designed to exercise arithmetic computations or algebraic manipulations. There are also factoring packages that exercise skills in solving equations. They give learners extensive repetitive work that reinforces concepts previously taught.

Table 3.5. Examples of drill and practice packages.

Package	Level	Description
Algebra blaster	Secondary	Pre-algebra and algebra software.
Addition and subtraction of story problems	Secondary	Helps learners practice addition and subtraction.
Beginning mathematics -word problems	Secondary	Solves word problems in addition, subtraction, division and multiplication.
Mastering mathematics	Secondary	Provides drill and practice using real numbers.
Stuckybear word problems	Primary	Motivates learners to work at solving word problems.
Integer fast facts	Primary	Teaches addition, subtraction, division and multiplication.
Magic grid	Secondary	Provides learners with an opportunity to practice equation-solving skills.
SERGO	Primary, secondary and tertiary	A comprehensive mastery learning package.
Graph-calc	Tertiary	Designed for pre-calculus and calculus classes.

Table 3.5. Continuation.

Package	**Level**	**Description**
Algebra drill and practice	Secondary	Offers drill and practice in solving linear equations and systems of linear equations in two or three variables.
Problem	Tertiary	For any exercise in which learners must calculate numerical results from numerical data.
CAMI maths	Secondary	Covers all aspects of secondary school syllabus under algebra, trigonomerty, geometry and graphs.

Grabe [12, p92] is of the opinion that, "drill and practice packages should not be used to introduce new concepts in mathematics as they have a too narrow approach to helping learners understand new material". The learners' initial exposure to academic facts or skills is often insufficient for an adequate level of mastery. Extended study may be required before facts or skills can be considered mastered. This is where drill and practice packages can be introduced. They are developed to meet the needs of the third stage of instruction, the extended practice stage. They are, thus, appropriate after learners have advanced past the guidance phase of instruction.

According to Grabe [12, p93], "the exact proficiency learners should develop varies with the type of content. For factual information, the expectation is that learners will be able to effortlessly retrieve the information from memory. With procedural skills, the expectation is that learners will be able to perform quickly, smoothly, and with few errors. In cases where learners are not able to do so, drill and practice packages may be integrated".

Smith [28, p2] is of the opinion that, "drill and practice packages reinforce learners learning by correct answers and they are able to identify those areas in which their knowledge is inadequate". Instructors are able, by keeping track of learners' records, to determine topics in which the learners need further training. Quoting Jones [19, p1], "instructors can modify the content, using drill and practice, to fit the lesson they are teaching". For example, a good drill software for spelling allows the instructor to input learners' current spelling list or particular words with which particular learners have difficulty. Repeated practice may help learners to internalise skills to make them automatic so that they can apply them to real-life situations.

Some packages often include branching features that establish an appropriate starting point for learners and avoid unnecessary repetition of previously mastered concepts. The level of difficulty is automatically adjusted during operation. This keeps learners from becoming bored and from needless repetition or frustration arising from material being too difficult for their present level of understanding. This reinforcement motivates learners. According to Walker [37, p735], "lessons based on drill and practice packages are usually more self-paced than traditional ones, and allow learners to control the level of explanatory detail required". Explanatory feedback from errors enables learners to learn from their own mistakes.

Smith [28, p2] says that, "drill and practice packages sequence problems". With written problem sheets, the sequence of problems learners work on is determined in advance. Learners become bored by repetitive exercises and testing problems that they have already mastered. They profit from working on easier problems before proceeding further. Problems are characterised according to level of difficulty. Learners may begin to work at level 1 and move up to level $n+1$ when they have demonstrated mastery of level n, perhaps by doing five problems correctly in succession, or by meeting some other criterion of success. The computer keeps track of individual learners' histories so that they can re-enter the system where they left off. The diagnostic abilities of some of these packages are a facet where the computer is often better than the instructor. Even a very good instructor can hardly determine accurately what the exact abilities of each of his/her learners are in every subdivision of the subject.

Overusage of drill and practice packages may have a negative effect, however, producing boredom rather than excitement. This could lead to rote learning. Drill and practice packages may sometimes be boring, yet, for many learners, they become much more tolerable when lessons provide self-paced problems, and when creative graphics, animation, and sound are effectively employed for information. The same techniques may however be distracting for learners or may reinforce incorrect responses to problems.

3.7 Game packages

Instructional activities are categorised as games when the activities emphasise competition and entertainment. If the activity has a winner or a loser or focuses the learner on competing against established records or standards, the activity has game-like qualities. Educational games are generally drill and practice packages spiced up by using a fantasy format and having scoring options. Many packages are designed to give learners practice in problem solving as well as in particular subject areas, concepts and skills. They test cognitive skills and motor reaction time in a game-like atmosphere. Games that require logic or strategy play an important role in developing thinking skills which are crucial to learning. These packages are normally aimed at the primary and secondary phases of education.

Table 3.6. Examples of game packages.

Package	Level	Description
Minus mission	Primary	Helps learners to practice subtraction facts.
Green globs	Primary	Enables learners to write equations to create graphs that pass through certain points.
Number munchers	Secondary	Learners practice arithmetic skills by munching numbers.
Laser math	Secondary	Practices addition. subtraction and multiplication.
Math invaders	Secondary	Provides practice in basic addition. subtraction and multiplication.
Darts	Secondary	Designed to teach fractions.
Multiploy	Secondary	Provides a game to be played with addition. subtraction. or multiplication problems.
Songwriter	Secondary	Provides an interesting perspective on music and mathematics education.

Grabe [12. p97] maintains that. "educational games can be integrated at the beginning of the lesson in order to provide interesting ways to initiate related areas of study". This may also be done to activate existing knowledge and stimulate learners' interest in more traditional work that follows. Game packages provide an opportunity for learners to go beyond drill and practice of arithmetic skills. Learners can develop insights into number theory and problem solving. Computers keep records from one game to the next. and display high scores and the name of the current record holder.

According to Grabe [12. p98]. "game packages may be used to enhance competition and co-operation". Instructors may use educational games to reward an achievement. For instance. the instructor can allow those learners who always get their work done first to spend time with computer games. These packages can be used for the development of knowledge and assimilation, recall, reproduction, computational skills, mathematical attitudes, personal traits or interest. Individuals and small groups of learners can play these games.

3.8 Computer Algebra Systems

Computer algebra systems are powerful computer software packages that do symbolic as well as numerical and graphical mathematics. The appearance of computer algebra systems has had a significant impact on, in particular, the curricula of tertiary institutions. Computer algebra systems manipulate a formula symbolically. For example, they can be used to expand, factorise, find root or simplify an algebraic polynomial. These packages do symbolic differentiation, integration and find solutions to equations. Computer algebra systems have the capability to evaluate symbolic solutions, approximate numerical solutions, and produce graphically generated approximate solutions. They use commands similar to mathematical notation, which permit learners to clearly or easily draw functions and their derivatives, find roots of functions and derivatives, and obtain numerical graphical output. Computer algebra systems used in learning mathematics have good graphic capabilities and help facilities.

Table 3.7. Examples of computer algebra systems.

Package	**Level**	**Description**
Derive	Tertiary	Performs numeric and symbolic computations in algebra and calculus.
Mathematica	Tertiary	Performs symbolic integration and differentiation of functions and much more.
Maple	Tertiary	Performs symbolic integration and differentiation of functions and much more.

Table 3.7. Continuation.

Package	Level	Description
Matlab	Tertiary	Powerful package for solving problems in linear algebra and many more.
Mathcad	Tertiary	A numerical processor.
True basic	Tertiary	Finds the derivative of a function.
GAP	Tertiary	A system for computational discrete algebra with particular emphasis in group theory.
Reduce	Tertiary	Designed for general algebraic computations.
Felix	Tertiary	Designed for computations in and with algebraic structures and substructures.
Magma	Tertiary	Designed to solve computationally problems in algebra, number theory and combinatorics.
Macsyma	Tertiary	Solves systems of equations and much more.

According to Walker [36, p425], "computer algebra systems can be integrated in class after the theory has been covered". One of the reasons for the introduction of computer algebra systems into the class is that learners lose time in getting started with real calculations. This distracts their attention from the problem to be solved.

Computer algebra systems enable the instructor to ask open-ended questions with the confidence that learners will attempt to find the answers. For example, the instructor may ask about the integral of expressions of the form $(a + bx + cx^2)^q$. Questions like this are beyond the capabilities of first year learners who do not have access to computer algebra systems. In modelling problems, there is the opportunity to concentrate on setting up the problem and interpreting the solution, while leaving the solution of the mathematical equation to the packages. Instructors of undergraduate courses are, thus, able to enhance their teaching by using computer algebra systems.

When drawing graphs in calculus, much time is spent in finding the derivative of the function and in the determination of critical points. By the time learners get to the point where it is possible to use the information obtained to sketch the curve. a lot of work has already been done. The learners rush through the main part of the exercise with the feeling that important parts have already been done. This is a poor use of learners' time. The use of these packages force learners to concentrate on the topic of the assignment. The removal of the manipulation phase of solving the problem forces learners to concentrate on processes of setting up the problem and analysing the results of the manipulation to solve the problem. The amount of manipulation involved in developing many mathematical concepts gives learners the false idea of the importance of the manipulative section of the development process. With computer algebra system packages. more time can be spent on the actual idea of the concept.

The use of a computer algebra system provides great opportunities for allowing learners to experiment. analytically as well as numerically. without the tedium of complicated algebraic manipulation. Burn [7. p62] reflects that. "although the need for a grasp of the basic manipulative skills will always remain. the use of computer algebra systems will open up many more courses to learners whose algebra is relatively weak. and will enable them to follow mathematical courses avoiding frustrations caused by elementary errors of manipulation".

Quoting Smith [28. p60]. "for many learners there are only two problem-solving skills. These are finding a suitable worked example to mimic. and carrying out algorithmic computation. To be effective solvers. learners need to consider alternatives. to experiment. to conjecture and test. and analyse results". Shifting the burden of computation to a computer algebra system makes time available for learners to concentrate on how to approach a problem. consider alternatives and experiment. It may also make time available for concentrating on concepts and processes rather than on the mastery of algorithms. According to Smith [28. p32]. "computer algebra systems allow learners to gain experience in combined use of symbolic. numerical approximation. and graphical methods for solving problems".

The value of the computer algebra system as an educational tool is dependent on the type and objectives of the task for which it is to be used. According to Smith [28, p40], "using a computer algebra system for a homework assignment to differentiate or integrate a collection of functions from a standard calculus text would be a waste of time, yield a negative learning and lead to the 'button pushing robot' syndrome". These packages may effect changes in computational skills. For instance, there may be a decrease in learners' abilities to recall and carry out many standard algorithms, such as those for factorising and integrating.

3.9 Simulation packages

Before jet pilots are allowed to pilot certain planes for real, they are required to practice in a flight simulator, a computer-driven environment where the pilot sits in a realistic cockpit and is put through training exercises. The pilot manipulates the cockpit controls and the computer produces reactions simulating those that the pilot would experience if he/she were actually in flight. According to Kelman [20, p48], "a simulation is a representation of a real-world situation in which a specified number of factors can change, as they do they produce other changes throughout the simulated world". Simulation is the modelling of reality to understand and solve problems. Simulations are designed to highlight the relationships between particular variables in the real world. They provide controlled learning environments that replicate key elements of real-world environments. A simulation's focus on a limited number of key elements provides a simplified version of the real world that allows the learner to learn a topic or skill effectively. A simulation is designed so that actions the learner takes within a simulated environment produce results similar to those that would occur in the actual environment.

Table 3.8. Examples of simulation packages.

Package	Level	Description
Sell apples, plants, lemonade	Primary	Simulates businesses that sell apples. plants and lemonade.
Furs, nomad, sumeria, voyageur	Primary	Encourages learners to apply their knowledge of four basic operations with rational numbers.
The Oregon trail	Secondary	Teaches basic operations and logical steps in problem solving.
South dakota	Secondary	Requires learners to make farming decisions involving mathematical skills.
Monte-Carlo	Secondary	Enables learners to introduce statical variation into simulation models.
Explorer metros	Secondary	Designed to give learners experience in using estimation.
Survival math	Secondary	Provides learners with the opportunity to apply and integrate arithmetic skills in realistic situations.

Grabe [12. p83] says that. "simulations can be integrated before formal presentation of new material to stimulate learners' interest. to activate what learners already know about the topic. and to provide a concrete example to relate to the more general discussion that follows". These can also be integrated after learners have been exposed to a new topic. In this approach. simulations allow learners to attempt to transfer what they have learnt to an actual application. and so perhaps reveal misconceptions. Computer simulations provide practical alternatives to certain hands-on activities requiring expensive equipment. dangerous materials. trips outside of the school or other time-consuming processes.

These packages do provide opportunities to apply mathematical skills in interesting and practical settings. The simulation approach attempts to place the learner in a real-world situation in which choices are presented, where he/she must make decisions and then face the consequences of those decisions. Some of the simulations place learners in a problem-solving environment and teach them to apply mathematics to real-life situations. The packages allow learners to see entities that may be invisible or difficult to see when working with real-world problems.

The simplification allowed by a simulation package helps learners to focus on critical information or skills and makes learning easier. Simulations also allow learners to observe phenomena that are not normally visible, and to control processes that are not normally controllable. They put learners in control of situations with which they would seldom be allowed to experiment under any other circumstance. In certain situations, simulations provide quality experiences at a reasonable cost.

Simulation packages set up a world that is governed by a limited set of rules. Thus, learners are given little information about the source or reason for these rules. Through interaction with artificial worlds, learners learn something about hypothetical thinking, but they do not develop any sense of what is required to construct a simulation package in the first place. It is also difficult to find optimal solutions using simulations. The only way to attempt to optimise using a simulation package is to make a change and run a simulation package to see whether an improvement has been achieved or not, and repeat. Large amounts of computer time can be consumed by this process.

Chapter 4

Conclusion

[illegible]